Role of bottom sediments in forming the radiation dose to fish of different species Kiev reservoir

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Abstract. The formation of absorbed dose for different species of fishes Kiev reservoir from incorporated radionuclides, water and bottom sediments in 2009 was studied. In work are used the data about contents of radionuclides in water, bottom sediments and fish. The distinct migratory behavior of fish and the spatial distribution of radionuclides in bottom area was considered. Absorbed dose from incorporated ^{90}Sr and ^{137}Cs for fish was from 10 (*Hypophthalmichthys molitri*) to 112 (*Esox lucius*) μGy/year. At the average dose from incorporated radionuclides beside predators in 3-4 times above, than beside fish not ravenous types. Absorbed dose from water did not exceed 0,3 μGy/year. Dose from bottom was depended on level of contents ^{137}Cs in bottom soils, on particularities of vertical distribution of fish of different types in water masses and on time of stay of fish in zone of influence of bottom sediment. Most absorbed dose from bottom sediments during the year was typical of *Tinca tinca* and *Carassius auratus* (7700 μGy/year) from higher part of Kiev reservoir. Got results are evidence, that total absorbed dose during the year of fish Kiev reservoir on 90 % was conditioned on bottom sediments.

1.INTRODUCTION

At present days, the significant problem of radiobiology is studing of small doses ionizing radiation influence on biological systems. If absorbed dose rate by alive organisms is within physiological or ecological disguise it is difficult to define the correlation between "dose - effect".

It is especially difficult to define the dose load on organisms of rolling forms of hydrobionts in water ecosystems. First of all, it is about representatives of ichthyofauna as far as the nature of vertical distribution in water masses and behaviour during fattening and wintering differs according to the species of fish.

The aim of work - estimation of influence of behaviour of fish of different species from Kiev reservoir on forming the absorbed dose with taking into account the levels of radionuclide pollution the components ecosystem.

2. MATERIALS AND METHODS

In work were used the data about contents of radionuclides in water, bottom sediments and fish. The objects of study were: *Rutilus rutilus* L. - Roach; *Tinca tinca* L. - Tench ; *Blicca bjoerkna* L.- White bream; *Abramis brama* L. - Bream; *Carassius auratus* gibelio (Bloch).- Goldfish; *Hypophthalmichthys molitrix* Valenciennes - Silver carp; *Silurus glanis* L. - European catfish; *Esox lucius* L.-

Pike; *Stizostedion lucioperca* L. - Pike-perch; *Perca fluviatilis fluviatilis* L. – Perch.

3. RESULTS AND CONCLUSIONS

The average annual content of ^{137}Cs in water masses in 2002-2008 didn't exceed 0.1 Bq/l [2]**.** It means that the radiation dose of fish from water didn't exceed 0.3 μGy/year**.**

The radiation dose to fish from the bottom sediments depends on concentration of radionuclides in the bottom sediments. The radionuclides in the ecosystem of large reservoirs are distributed on the area of bottom not evenly. For such case the dose of fish irradiation from the bottom sediments are expected on formula:

$$D = \Sigma\Sigma\ g_k\ P_i\ \ t_{ki},\ \ k=1,l;\ i = 1,n \qquad (1)$$

where P_i **-** the dose rate on a surface of the bottom sediments of different areas of reservoir, Gy/day**;** g_k - geometrical factor; t_{ki} - time of fish location in the zone of influence of the bottom sediments on different areas at a geometrical factor g_k, days; l - amount of periods with different meaning of g_k; n - amount of areas of reservoir with different dose rate on a surface of the bottom sediments.

In case, when vertical stratification of radionuclide contamination of the bottom sediments can be presented in approaching of endless geometry, the dose rate on a surface of the bottom sediments calculates by the following formula [1]:

$$P = 0,5\ \Sigma C_{sed(i)}\ K_{\ d(i)(\gamma)},\ \ i = 1,\ n \qquad (2)$$

where $C_{sed(i)}$ - concentration of i – radionuclide in the bottom sediments, Bq/kg of natural humidity; $K_{d(i)(\gamma)}$ - dose coefficient of i – radionuclide, (Gy/day)/(Bq/kg). Thus, the absorbed dose depends also on the migratory behavior of fish, geometrical factor of radiation (g_k) and time of radiation in these conditions (t_k).

For the calculation of the dose loadings on the organism of fish from the bottom sediments we took into account their fattening and wintering periods, and unfavorable meteorological conditions. Besides, we have selected four levels of fish location concerning the bottom sediments: 1 – is staying in thickness of the bottom sediments; 2 – on a surface of the bottom sediments; 3 – on the distance about 50 cm from the bottom; 4 – on the distance more, than 50 cm from the bottom. For the fish of the Ukrainian reservoirs, the basic radionuclide that forms doses from the bottom sediments is ^{137}Cs. Therefore the size of geometrical coefficient of radiation was calculated for this radionuclide. For the fish, which is in the bottom sediments, the radiation dose corresponds to a dose created by gamma radiation in volume of the bottom sediments. On a surface of the bottom sediments the geometrical coefficient equals 0,5, on the 3-rd level – 0,05, on the 4-th – 0. For calculations we have allocated 8 temporal groupings (table 1). Grouping A(2) make typical both facultative benthophages and a benthonic predators which during the period of fattening not less than 40 – 60 % of time are on a surface of the bottom sediments; A(3) – the predators who are settling down in a zone of influence of the bottom sediments. Grouping A(4) form typical planktophages and the predators that pursuit their victim in water on the distance more, than 50 cm from the bottom. In adverse weather conditions almost all species of fresh-water fishes move on deep-water sites, and

unite in grouping B(2) [3, 4]. The fish, which are winter in thickness of the bottom sediments, form grouping C(1), in pits – C(2). The predators which are not plunging for the winter period in hibernation and planktophages, which are winter in thickness of water, form groupings C(3) and C(4).

Table 1. Specific structure of temporal ecological groupings of fish.

Levels	The fattening period	The period of adverse conditions	The wintering period
1	×	×	C(1): Goldfish, Tench
2	A(2): Goldfish, Tench, Bream, White bream, Roach, European catfish	B(2): Goldfish, Tench, Pike, Bream, White bream, Roach, European catfish, Perch, Silver carp, Pike-perch	C(2): Bream, White bream, Roach, European catfish
3	A(3): Pike, Perch	×	C(3): Pike, Perch
4	A(4): Silver carp, Pike-perch	×	C(4): Silver carp, Pike-perch

Note: - × for the chosen referential kinds the grouping doesn't form; A(i), B(i), C(i) - ecological groupings.

We have calculated the time of staying each species as a part of different groupings. It has allowed us to deduce factors of vertical distribution (K_v). They consider geometry of fish radiation and time intervals of staying fish of different species in zones, with different degree of influence of the bottom sediments (table 2).

Table 2. Coefficient of vertical distribution (K_v) for the industrial species of fish of the Kiev reservoir.

Species of fish	Periods		
	A	B	C
Goldfish, Tench	0,14	0,15	0,66
European catfish	0,29	0,20	0,33
Bream, Roach, White bream	0,14	0,15	0,33
Perch, Pike	0,02	0,2	0,03
Silver carp, Pike-perch	0,00	0,15	0,00

Usually, in a large reservoirs where there are difficult hydrological processes, there are more intensively polluted bottom sediments of deep-water sites with ^{137}Cs (in pits and water areas where fishes are located during adverse weather conditions). Thus, the formula 1 is for radiation dose from ^{137}Cs, deposited in bottom sediments, taking into account the formula 2 and coefficient presented in table 2, will look like:

$$D = 0{,}5K_{\mathbf{DOS}}\,[C_{\mathbf{A}}\,K_{\mathbf{V(A)}} + C_{\mathbf{B}}\,K_{\mathbf{V(B)}} + C_{\mathbf{C}}\,K_{\mathbf{V(C)}}\,]365 \qquad (3)$$

Now we can estimate a total dose of an internal and external fish radiation of the Kiev reservoir from different sources. On the basis of our data about the maintenance of ^{90}Sr and ^{137}Cs in organisms of fish of different species, in 2009 it was established that radiation dose to fish of the Kiev reservoir from the incorporated radionuclides made 10.2□ - 112 μGy/year (Fig. 1). Thus authentic distinctions of levels of dose loadings for the fish of the same species, which were caught on different sites of the reservoir, was not registered.

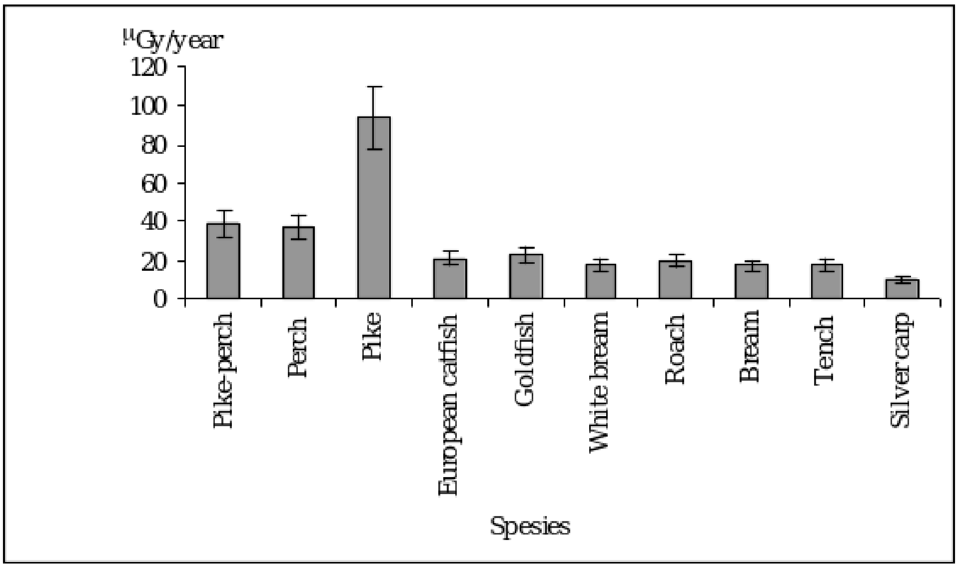

Figure 1. Radiation dose to fish of the Kiev reservoir from the incorporated radionuclides, 2009.

On the territory of the Pripyat spur of the Kiev reservoir, in places of fattening of the majority benthophages species of fish, concentration of ^{137}Cs in a bottom makes approximately 2000 Bq/kg. For more deep-water sites where fishes are in storm, sizes of an order 3500 are typical, for pits – 7000 Bq/kg of natural humidity. For the bottom sediments of an average and lower part of the Kiev reservoir, in places of fattening sizes of an order 100 are typical, for the deep-water sites and pits – 1700 Bq/kg. Taking into account these value we have defined an annual radiation dose to ichthyofauna of the Kiev reservoir from the bottom sediments (Fig. 2).

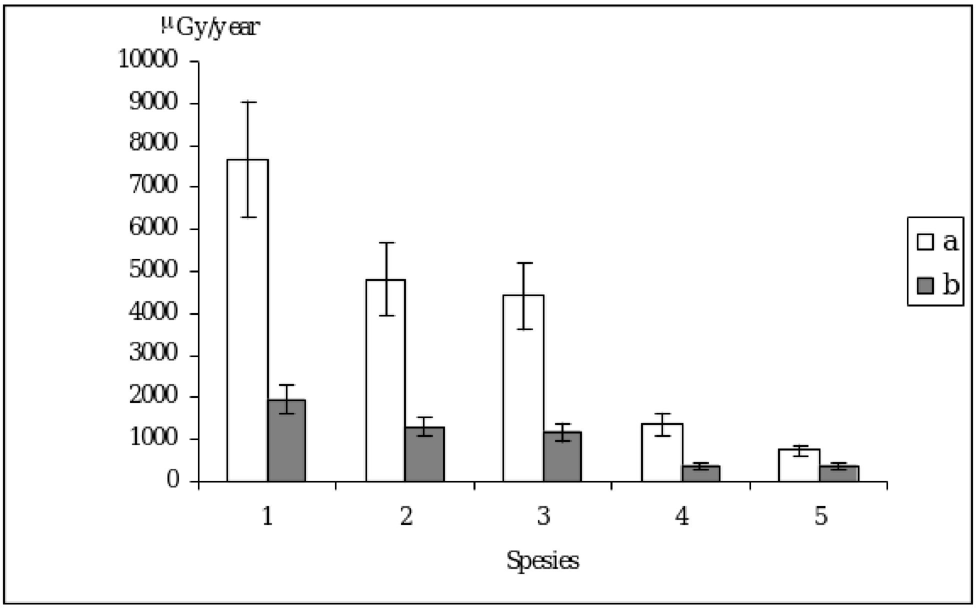

Figure 2. Radiation dose of fish of the Kiev reservoir from the bottom sediments, 2009; a – the Pripyat's spur, b – an average and lower part; 1 - Goldfish, Tench; 2 - European catfish; 3 - White bream, Roach, Bream; 4 – Pike, Perch; 5 - Pike-perch, Silver carp.

Thus, the biggest annual doses are characteristic for a Goldfish and a Tench, and the least – for the pelagic fish – Pike-perch and Silver carp. It is necessary to notice that at the present stage water masses bring in total radiation dose of fish of the Kiev reservoir less than 0,1%, the incorporated radionuclides – not more than 10 %.

Reference

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